

Session CC12A : Exploring the Ecological Responses of Estuarine, Coastal, and Open Ocean Waters to Climatic Drivers

Usually fewer diatoms during mild winters in a pristine Mediterranean coastal site

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Context

The Mediterranean basin is a **biodiversity hotspot** that is crucial to human health, food security, economies, and livelihoods. However, it is under threat from human overexploitation and **climate change**.

There is a consistent **warming trend** in the Mediterranean sea surface temperature (SST) for almost 40 years, but warming rates present a noticeable spatial variability and differ geographically (e.g. Macias et al 2013,

Pastor et al 2020 , Pisano et al 2020).

In Mediterranean open waters, no significant overall decline/increase in **phytoplankton** biomass (chl *a*) or earlier/delayed timings of the seasonal peak are observed over the entire basin during the 1998-2014 period (Salgado-Hernanz et al. 2019), but large regional variations exist.

Noticeable changes in the estimated phytoplankton community composition are observed over the period 2003-2020 : diatoms and haptophytes dominance are replaced by cyanobacteria (El Hourany et al. 2021).

In coastal waters, most phytoplankton time series are acquired in **areas (strongly) affected by local human activities**. Contrasted trends in phytoplankton biomass (increase, decrease, e.g. Ribeira d'Alcalà et al. 2004, Nunes et al. 2018, Totti et al. 2019), community structure (e.g. Cabrini et al. 2012) and phenology (e.g. Cerino et al. 2019) are observed.

Context and objectives

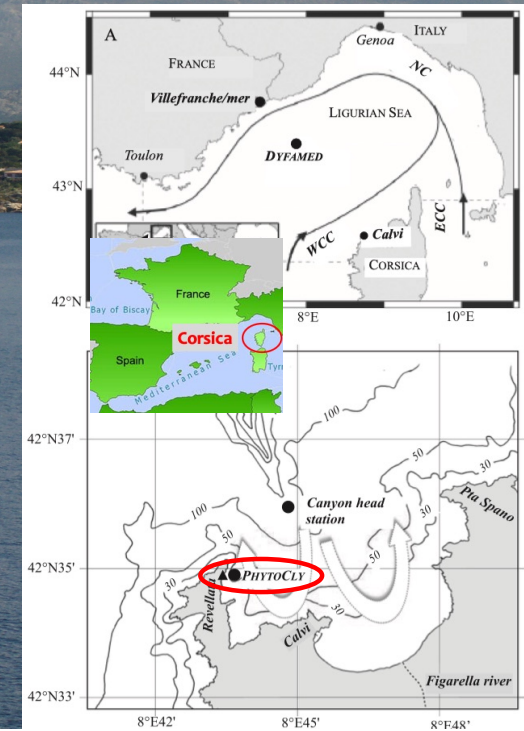
In a well-preserved NW Mediterranean coastal area (PHYTOCLY site, Calvi Bay, Corsica, Ligurian Sea), previous studies (Goffart et al. 2002, Goffart et al. 2015) have shown that winter intensity, through the associated upward flux of nutrients, is a key driver of winter-spring phytoplankton blooms. Here we use a long-term time series (14 years, 2007-2020) of field data collected at the PHYTOCLY site to investigate the relationships between winter intensity and surface phytoplankton characteristics throughout the year.

WII is a proxy of winter intensity in the Calvi Bay (Goffart et al. 2015).

$$WII = (CW \times WE) / 1000$$

- CW is the duration (number of days) of the cold-water period (subsurface water temperature $\leq 13.5^{\circ}\text{C}$);
- WE is the number of days characterized by a mean daily wind speed $> 5 \text{ m s}^{-1}$ during the cold-water period.

- Subsurface sampling at the PHYTOCLY site, 1-2 times per week between 2007 and 2020;
- Sampling mostly performed by STARESO SAS staff;
- 1 130 surface water samples for HPLC pigment analysis.

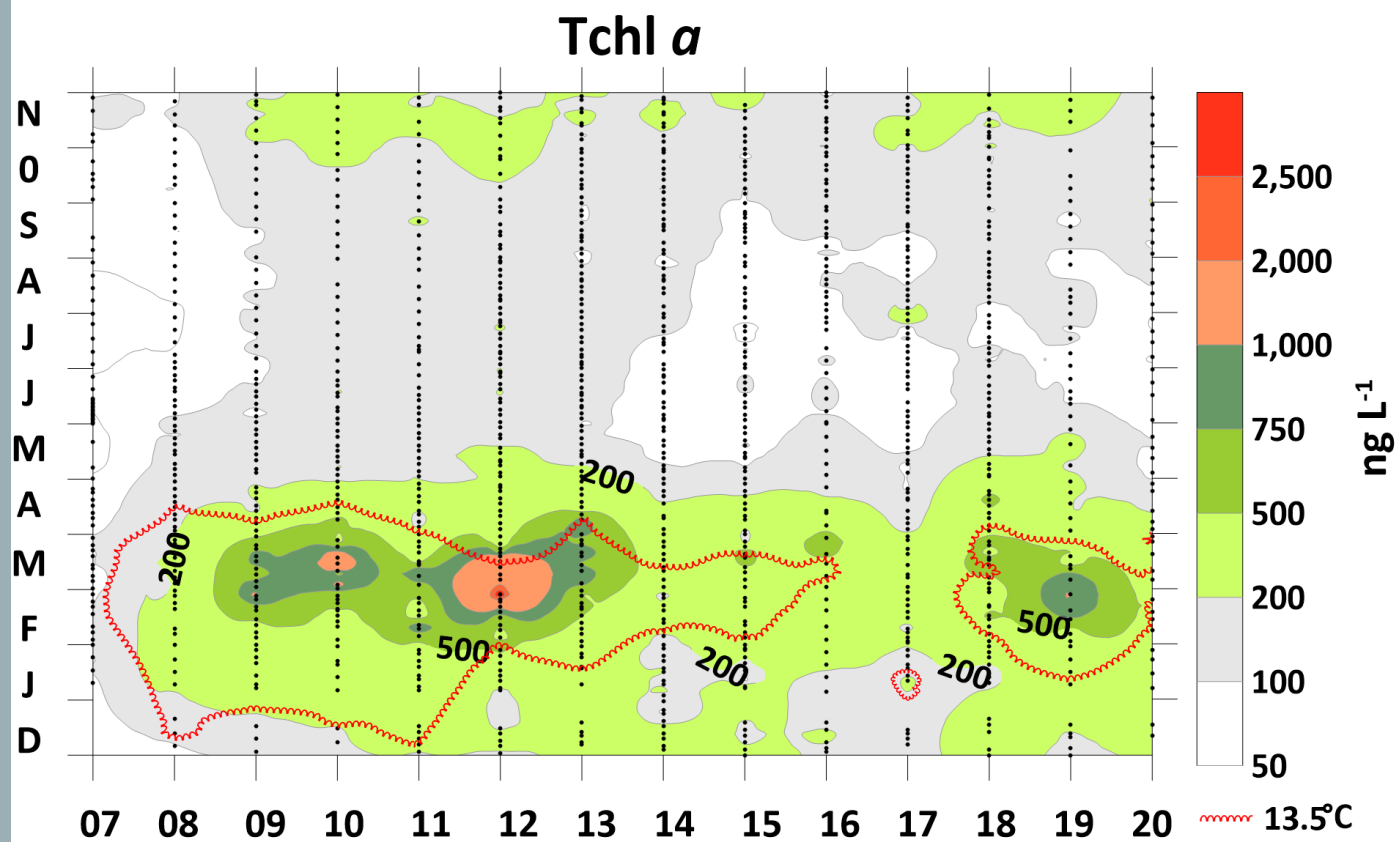


Total biomass (Tchl a) and relation with winter intensity at the PHYTOCLY site

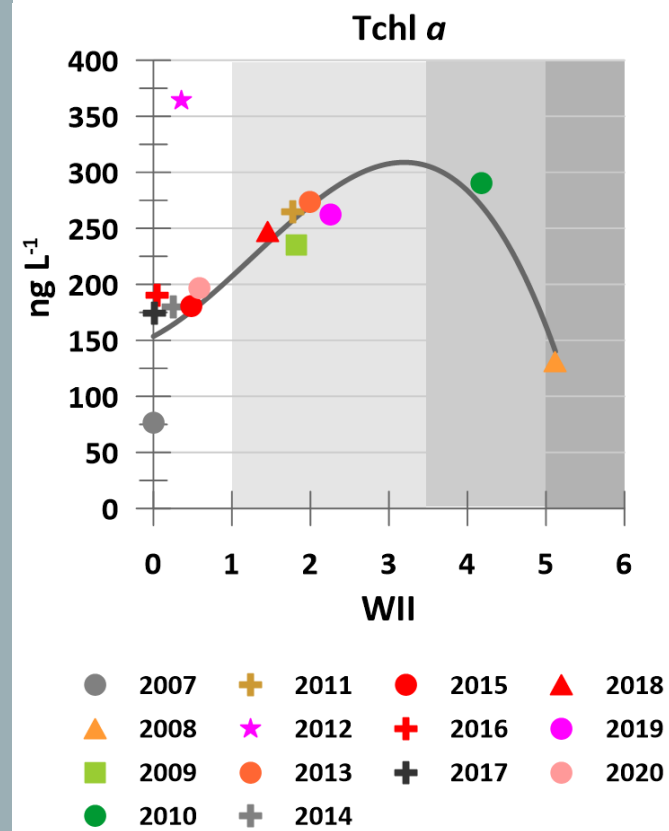
Seasonal and interannual variations of subsurface Tchl a between 2007 and 2020 at the PHYTOCLY site

(temporal changes from December of year $x-1$ to November of year x),

1 130 samples.



Scatter diagram of mean integrated annual subsurface Tchl a as a function of the Winter Intensity Index (WII).



WII, subsurface Tchl *a* and trophic regimes

Local scale
Basin scale



Winter with intense Deep Water formation in the Gulf of Lion, WII : not applicable
2012

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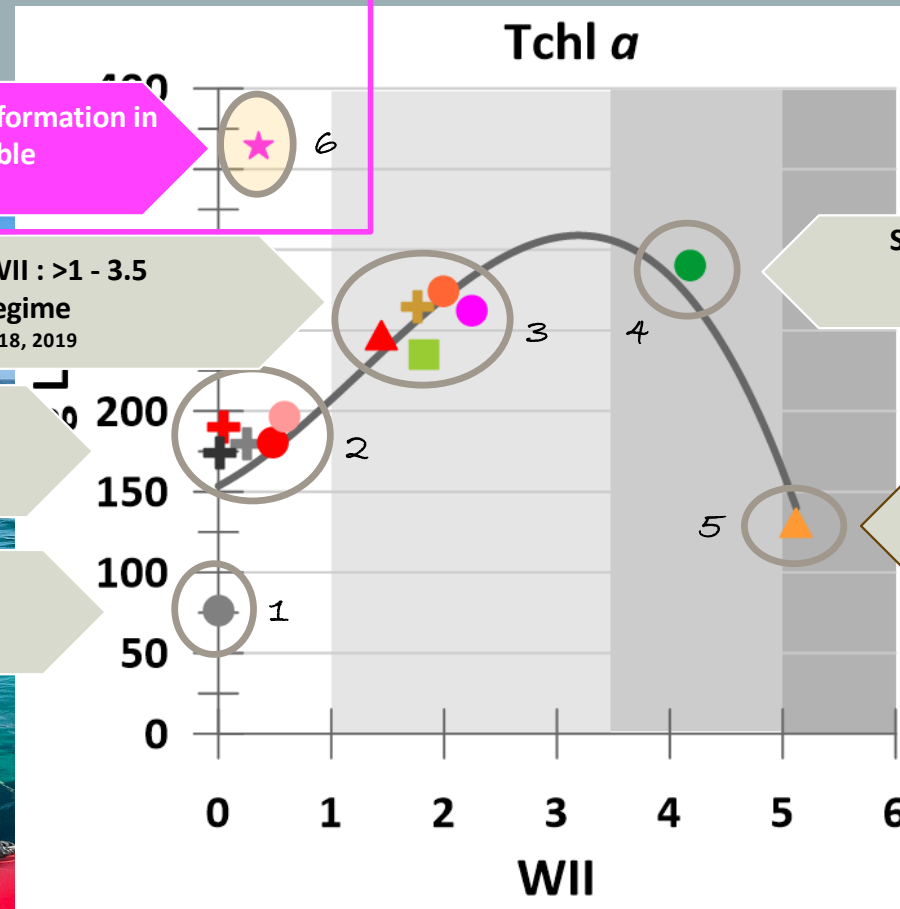
Moderate winters, WII : >1 - 3.5
Oligotrophic regime
2009, 2011, 2013, 2018, 2019

Mild winters, WII : >0 - 1
Very oligotrophic regime
2014, 2015, 2016, 2017, 2020

No winter, WII = 0
Ultra oligotrophic regime
2007

Severe winters, WII : >3.5 - 5
Mesotrophic regime
2010

Extremely severe winters, WII >5
High nutrients low chlorophyll regime (HNLC)
2008



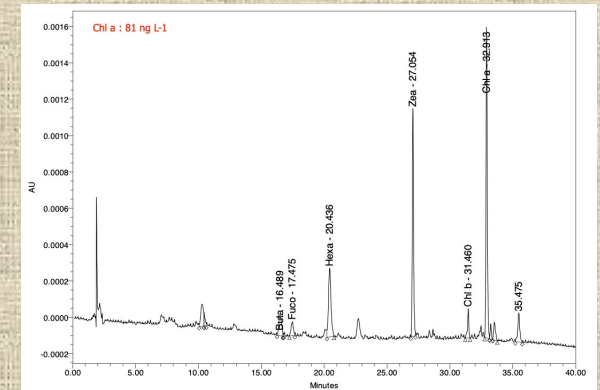
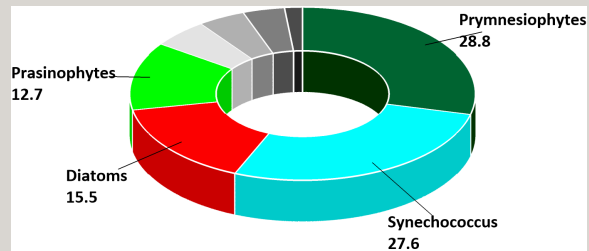
● 2007	+ 2011	● 2015	▲ 2018
▲ 2008	★ 2012	+ 2016	● 2019
■ 2009	● 2013	+ 2017	● 2020
● 2010	+ 2014		

Winter conditions and subsurface phytoplankton groups

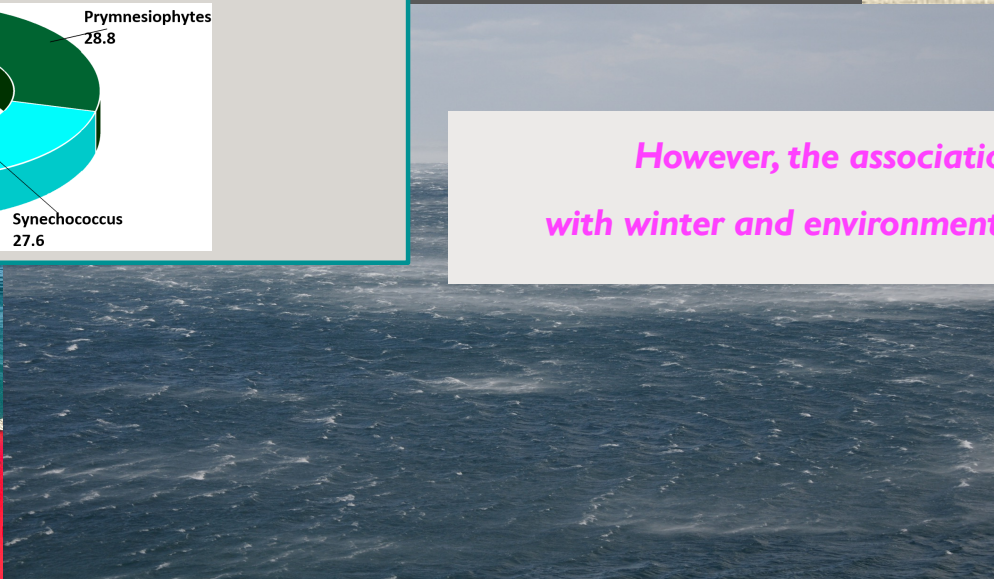
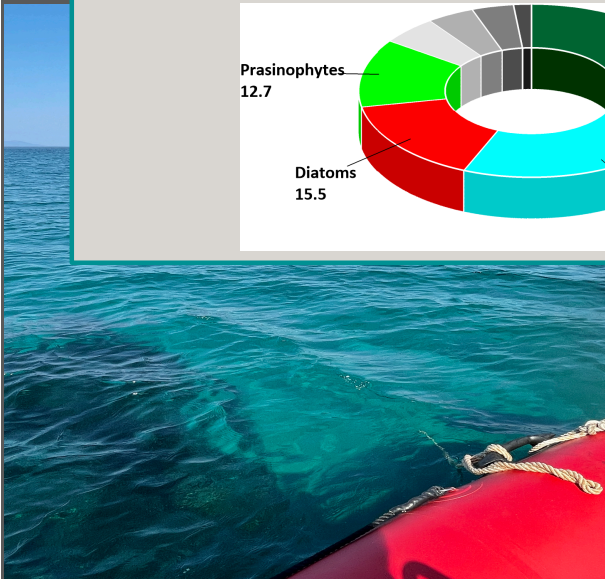
We use :

- ❖ HPLC to determine the concentrations of phytoplankton pigments in samples collected at the PHYTOCLY time series site,
- ❖ CHEMTAX to calculate the contribution of each group to Tchl a concentration.

From 2007 to 2020, the 4 most abundant groups in terms of Tchl a were prymnesiophytes, *Synechococcus*, prasinophytes and diatoms. Overall, they contributed 85% of the total phytoplankton biomass.

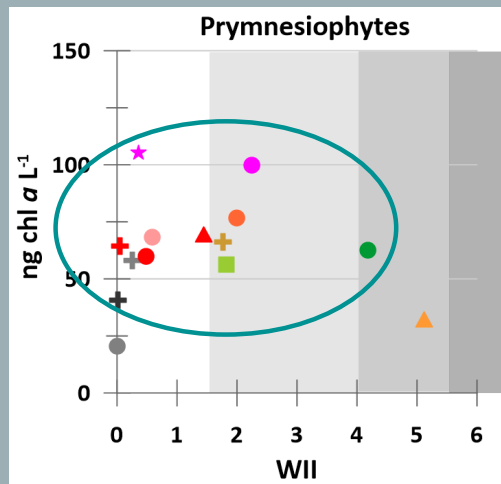
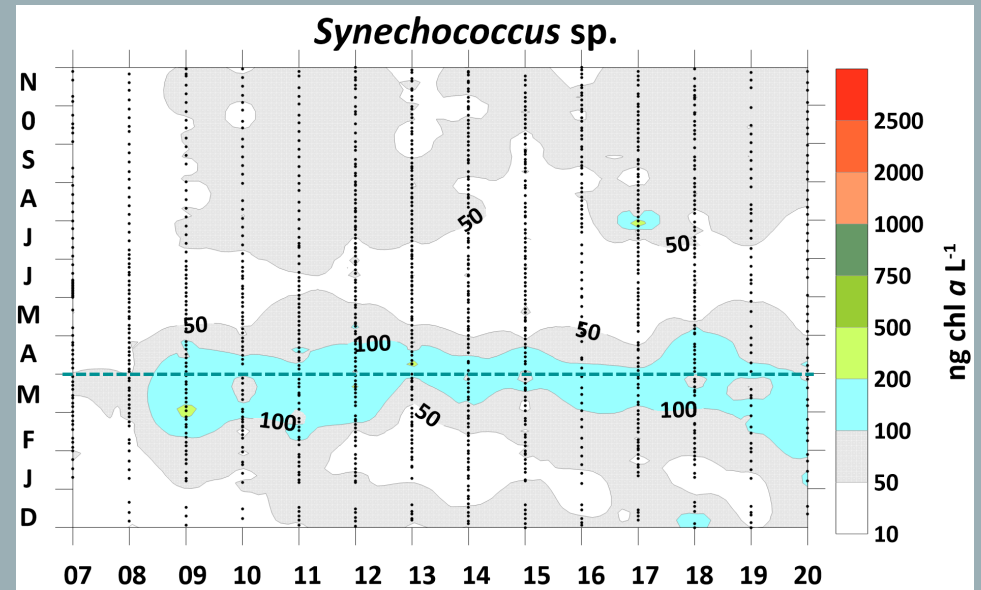
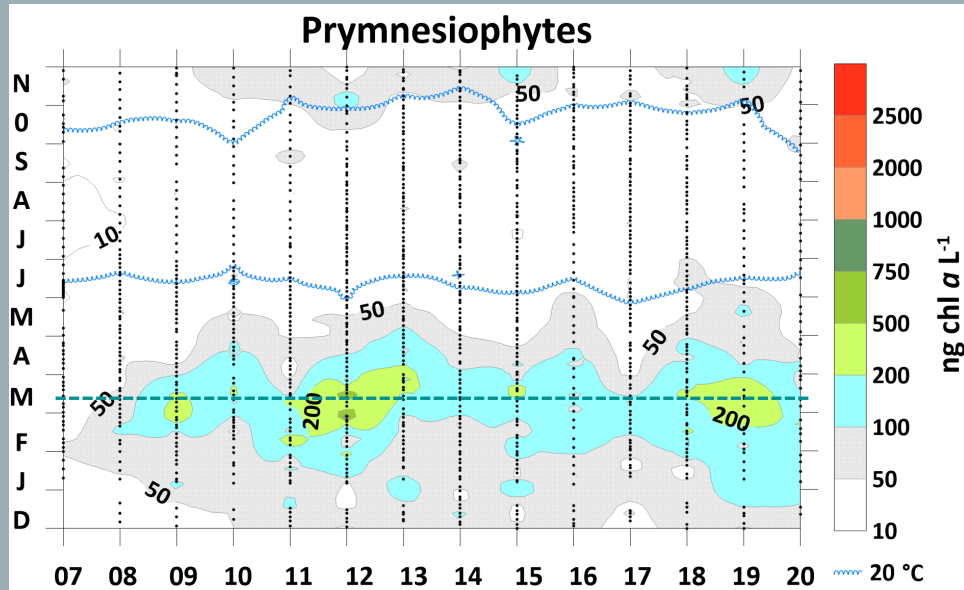


However, the association of these groups with winter and environmental conditions is lacking.

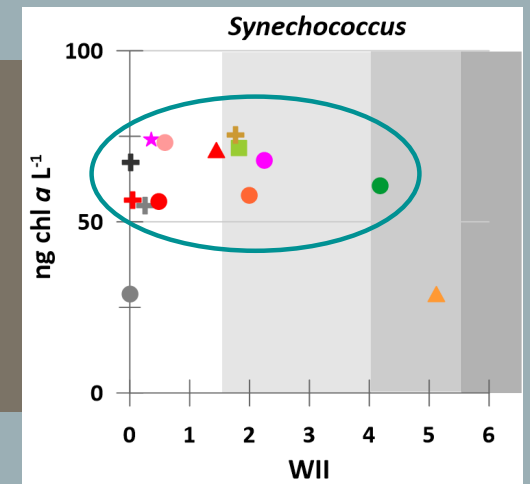


Winter conditions and subsurface phytoplankton groups

Seasonal and interannual variations of subsurface prymnesiophytes and *Synechococcus* between 2007 and 2020 at the PHYTOCLY site ; 1 130 samples.

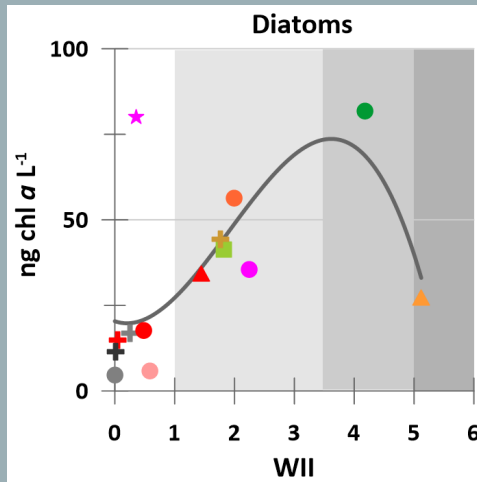
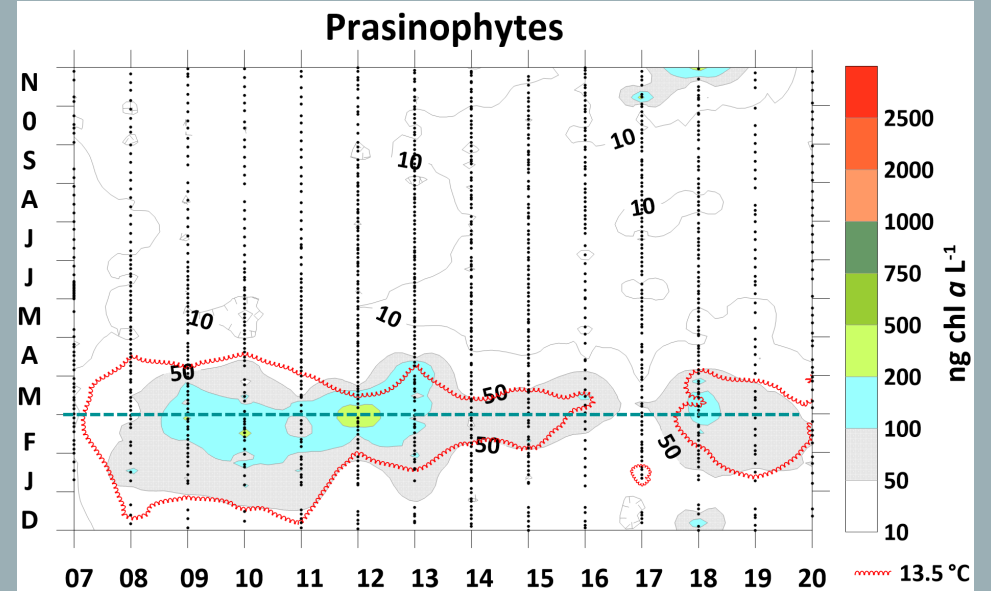
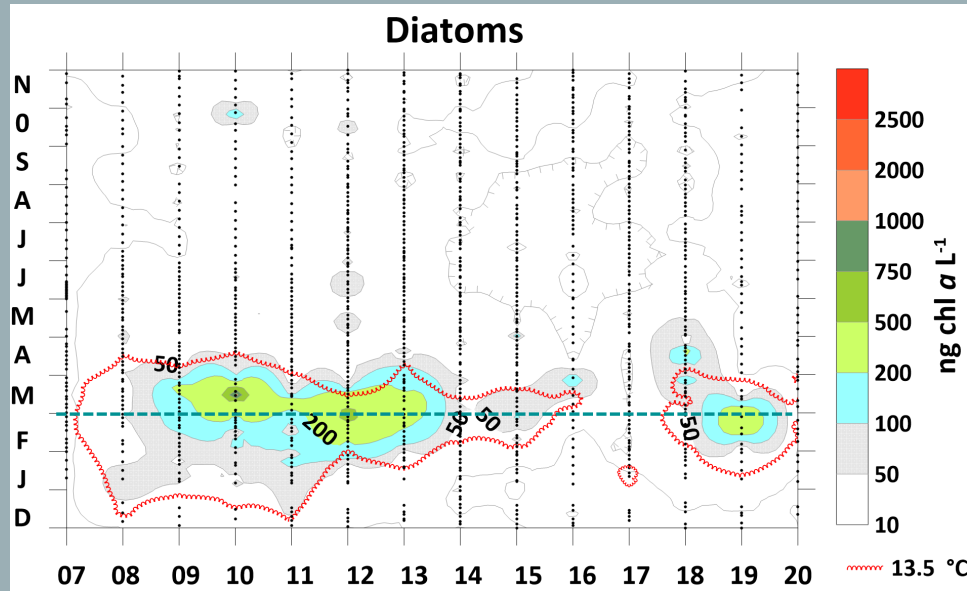


- Prymnesiophytes developed every year and peaked by mid-March. They were not observed when subsurface water was $> 20^{\circ}\text{C}$;
- *Synechococcus* developed every year and peaked usually in late March. Their growth is not limited by any temperature range ;
- Winter intensity is not an important governing factor for Prymnesiophytes and *Synechococcus* communities.

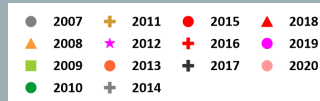


Winter conditions and subsurface phytoplankton groups

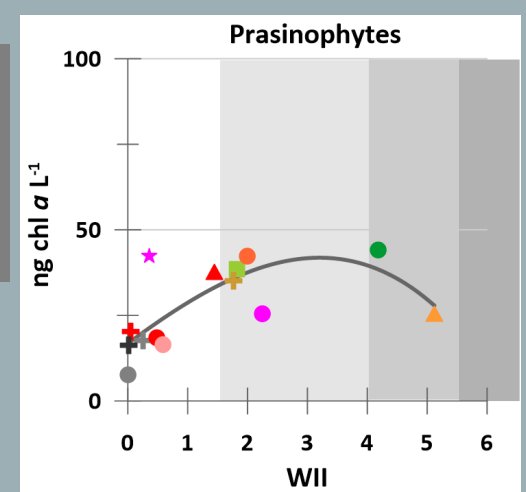
Seasonal and interannual variations of subsurface diatoms and prasinophytes between 2007 and 2020 at the PHYTOCLV site ; 1 130 samples.



- Diatoms and prasinophytes always increased and peaked during the cold-water period, when subsurface water was ≤ 13.5 °C ;
- They peaked by the end of February or beginning of March ;
- As *Tchl a*, their biomass is strongly controlled by winter intensity.



Scatter diagrams of mean integrated annual subsurface diatoms and prasinophytes biomasses a as a function of the Winter Intensity Index (WII).



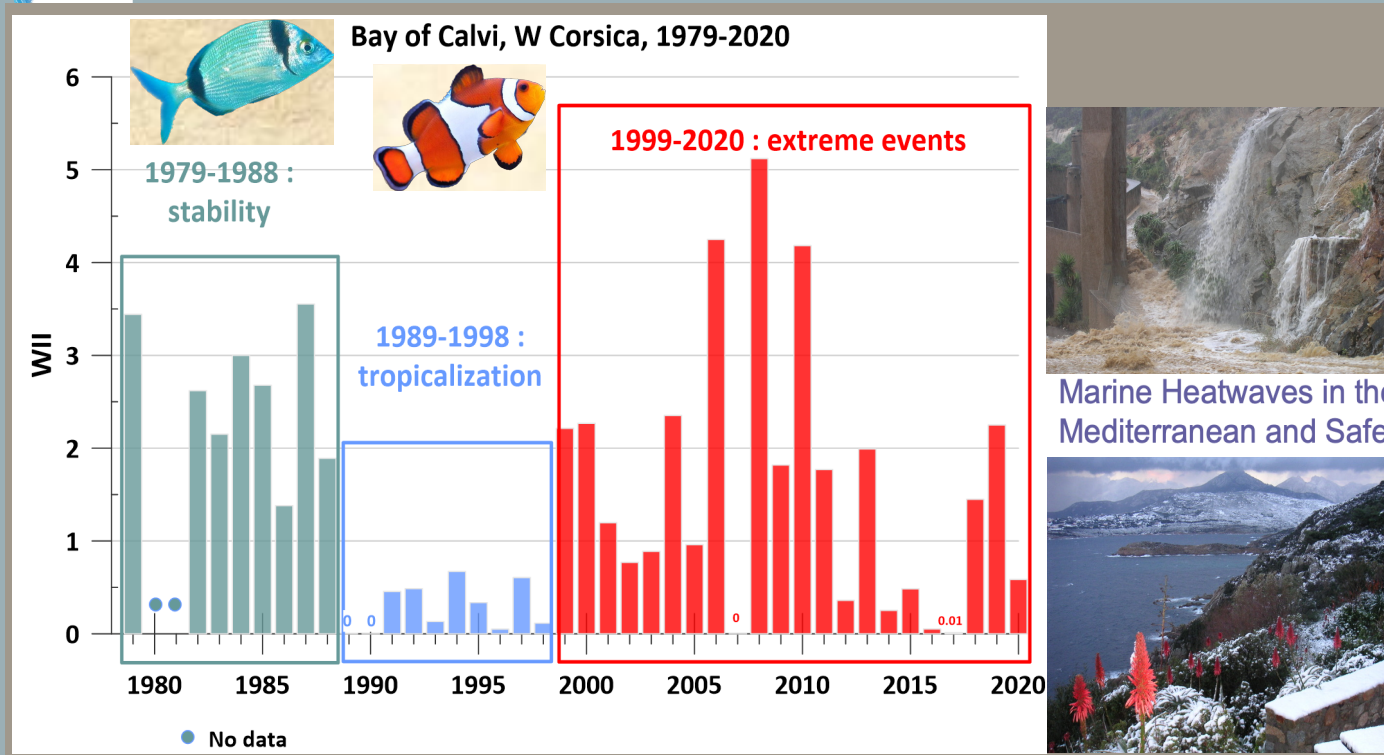
WII, Winter classification and contribution of diatoms to Tchl α

Winter conditions	No winter	Mild winters	Moderate winters	Severe winter	Extremely severe winter	Winter with intense deep water formation in the Gulf of Lion
WII range	0	>0.1 - 1	>1 - 3.5	>3.5 - 5	>5	
Years	2007	2014, 2015, 2016, 2017, 2020	2009, 2011, 2013, 2018, 2019	2010	2008	2012
Trophic regime	Ultra oligotrophic	Very oligotrophic	Oligotrophic	Mesotrophic	High nutrients low chlorophyll (HNLC)	Eutrophic
Annual mean contribution of diatoms to T chl α						
ng L ⁻¹	5	13 ± 5	42 ± 9	82	27	80
%	7	8 ± 3	16 ± 3	28	21	22
	<i>Local scale processes</i>					<i>Basin scale processes</i>

What about trends ?



No continuous trends in WII are observed, but there are evidences of decadal or multidecadal fluctuations affecting phytoplankton communities, both in term of total biomass and community structure.



Conclusions

This study, performed in a well-preserved Mediterranean coastal area (PHYTOCLY site, Calvi Bay, Corsica), demonstrates that, at the local scale :

- ❖ winter intensity is a key driver of phytoplankton biomass and composition throughout the year,
- ❖ winter intensity influences the interannual variability of the trophic regimes of the Bay of Calvi,
- ❖ diatoms are particularly sensitive to changes in winter conditions and associated upward flux of nutrients.

In some cases, processes occurring at the basin scale (*e.g.* intense episodes of Mediterranean Deep Water formation) override local ones.

This work provides valuable insights for :

- ❖ evaluating changes in phytoplankton community structure in a changing Mediterranean climate,
- ❖ developing/adapting phytoplankton biodiversity indicators that meet European policy obligations (*e.g.* Marine Strategy Framework Directive).



Thank you for your attention !